AIRS water vapor retrieval optimization using ARM CART SGP, TWP and NSA best estimate profiles

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Objectives

- **I. Background: AIRS water vapor and temperature retrieval validation**
- **II. Updates: AIRS water vapor retrieval optimization**

Motivations

- **Water vapor positive-negative feedback in the global climate change**: more than one decade of controversy
- **Outgoing longwave radiation & water vapor**: OLR is strongly sensitive to changes in water vapor, particularly in the upper troposphere layers from which much of the OLR escapes
- **Role of UT in the Water Vapor feedback**: of the total feedback from water vapor, current climate models predict that roughly two-thirds originate from the UT where humidity is relatively low.

I. AIRS water vapor and temperature retrieval validation

Latest validation results

- **Pre-launch accuracy requirement**: 20%, with the goal of 10% in 2 km layer thickness below 100 mbar

- **Validation 1**. (M. Divakarla et al.) :

Land: 25% (surface) – 45% (UT)

Sea: 15%(surface) – 35% (UT)

- **Validation 2**. (D. Tobin et al.):

SGP (97.5W, 36.6N), **TWP** (166.9E, 0.5S) , **NSA** (156.6W,71.3N)

Water Vapor RMS:

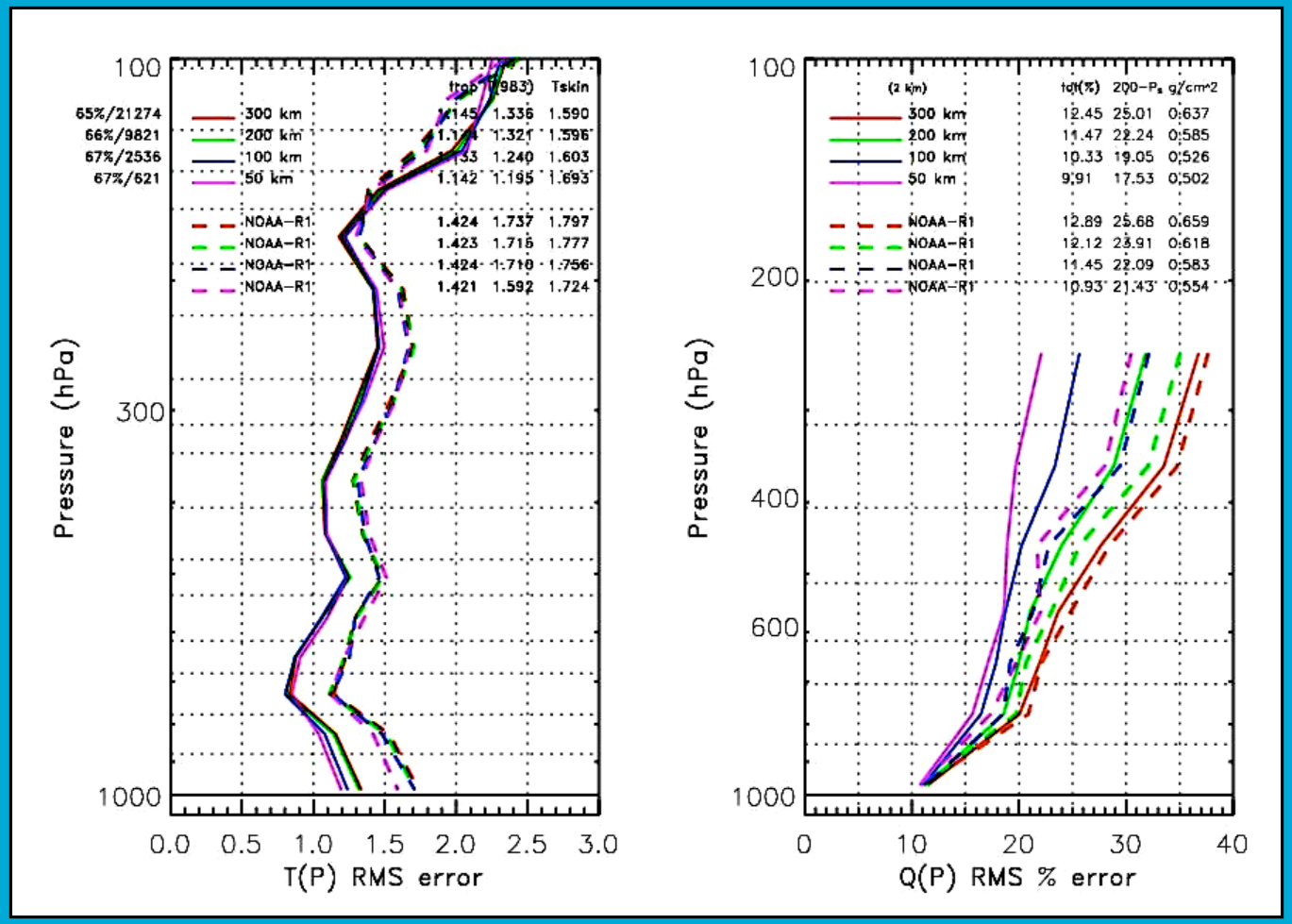
- **~25% below 500mbar, increasing to ~35% at 200mbar (SGP)**
- **~10% below 400mbar, increasing to ~20% at 200mbar (TWP)**

Water Vapor BIASES:

- **~5% below 400mbar, increasing to ~-10% at 300mbar (SGP)**
- **~5% below 400mbar, increasing to ~10% at 300mbar (TWP)**

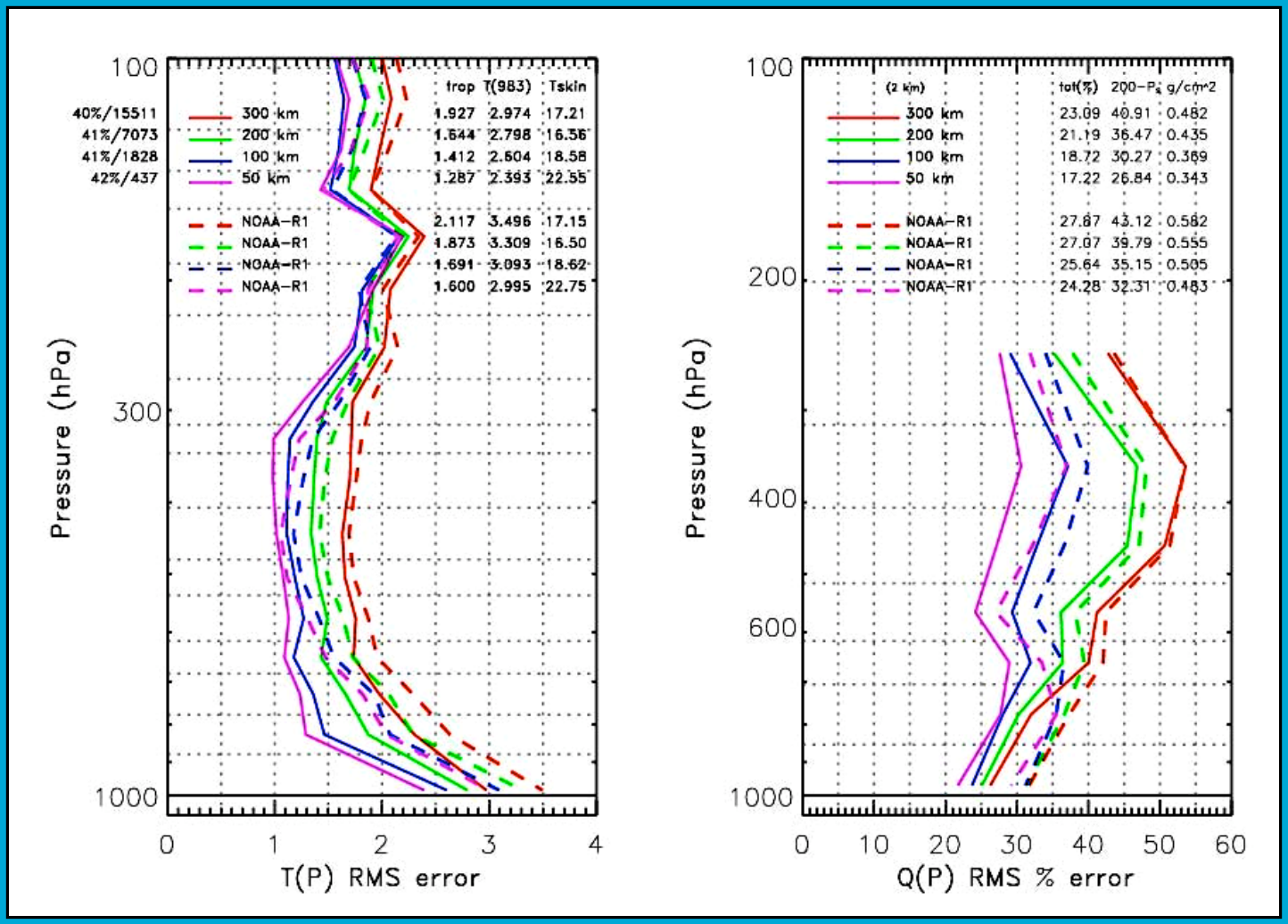
(2002-2004) – within 2 hours from overpass - 120km collocation

Spatial gradient characterization (TWP)



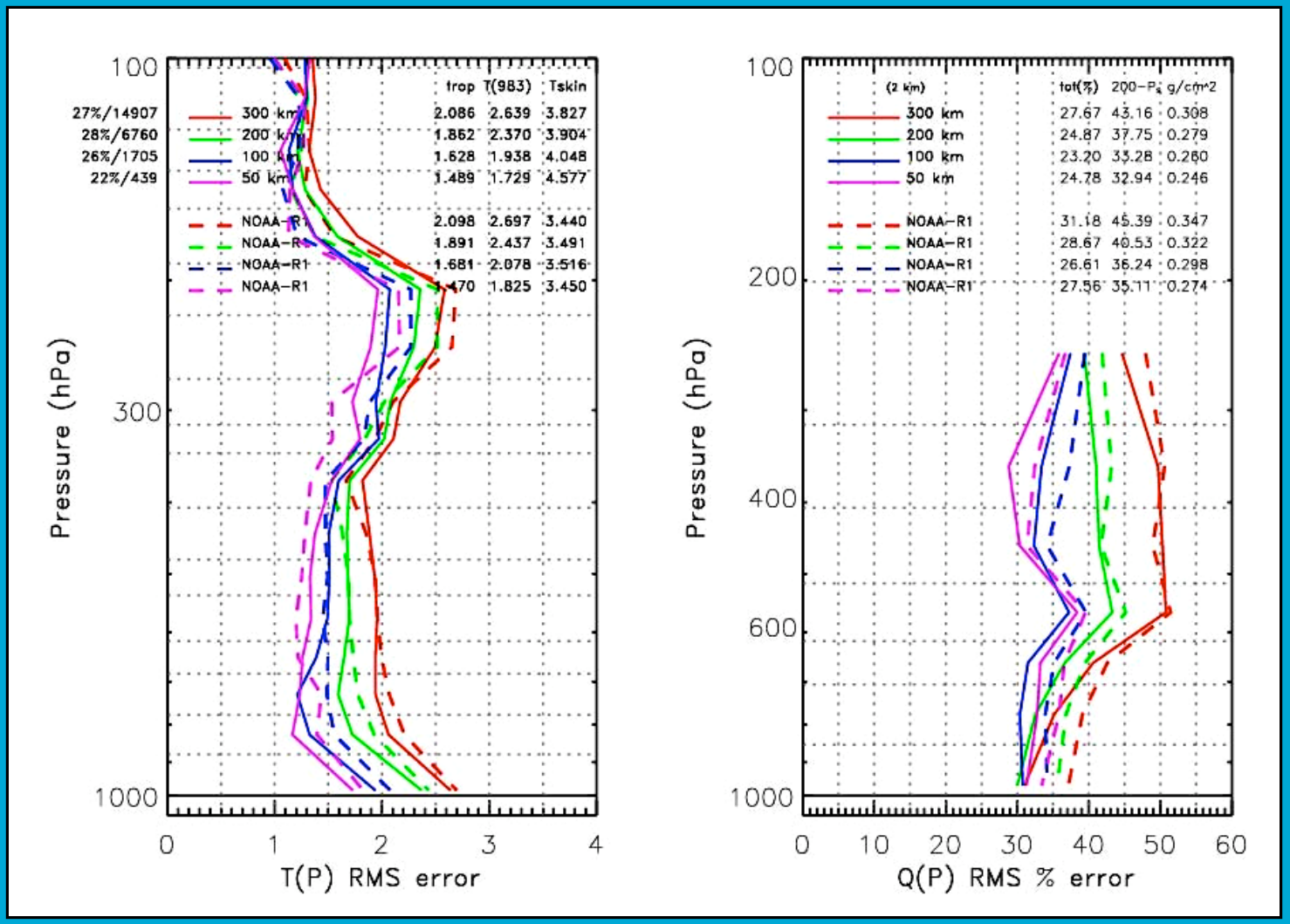
RMS spatial gradient in radiosonde-retrieval comparison

Spatial gradient characterization (SGP)



RMS spatial gradient in radiosonde-retrieval comparison

Spatial gradient characterization (NSA)



RMS spatial gradient in radiosonde-retrieval comparison

II. AIRS Water Vapor retrieval optimization

AIRS water vapor retrieval algorithm optimizations

- **The AIRS Product Retrieval Software (APS)** has been designed to derive several geophysical parameters including temperature and water vapour profiles, IR and microwave surface emissivity, total ozone and cloud parameters.
- This module solves for the solution of the linearized radiative transfer equation :

$$\Delta X_{L} = S^{-1}_{n,L} \cdot \Delta R_{n}$$

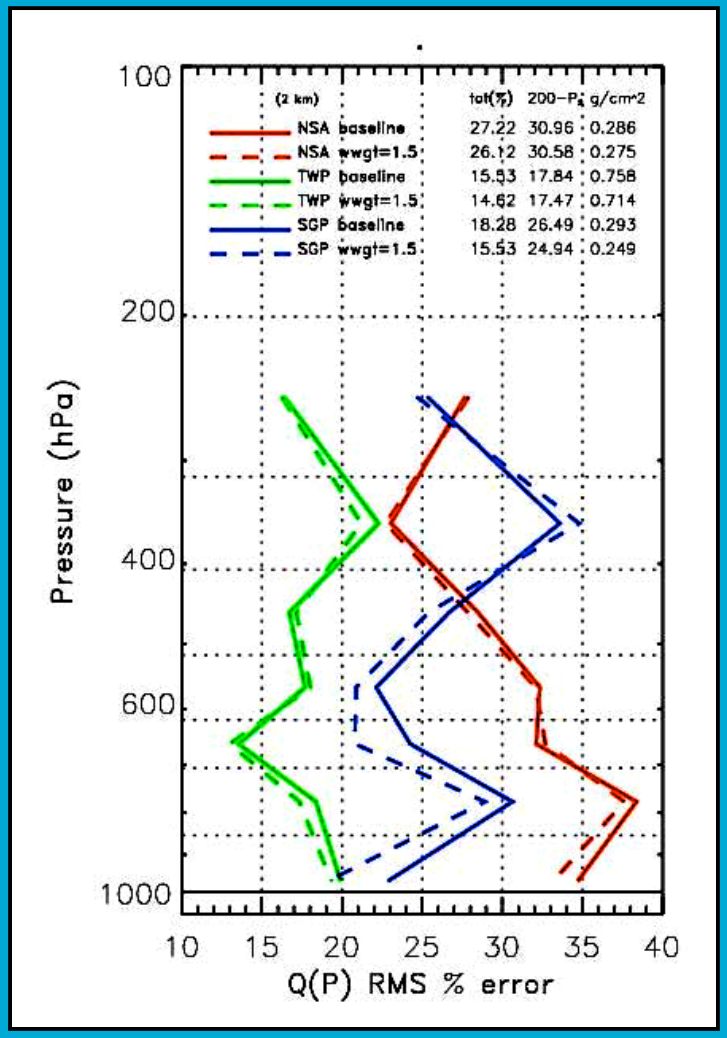
Possible optimization parameters:

- Regularization factor

-Perturbation Functions

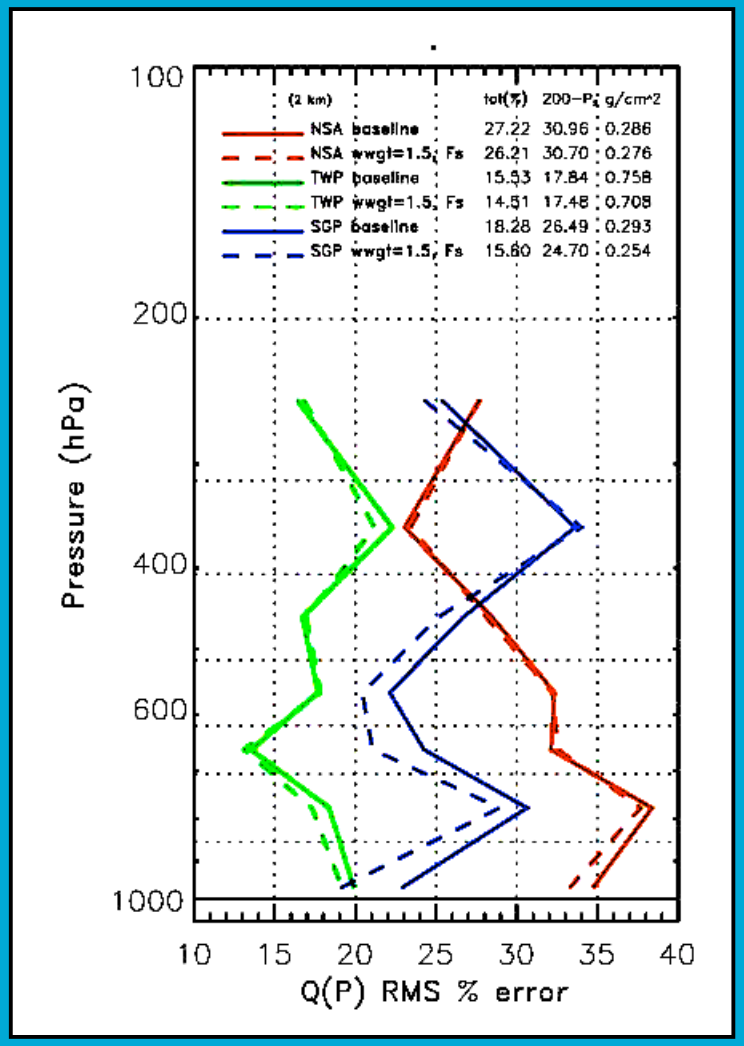
-Retrieval channel list

Regularization factor optimization



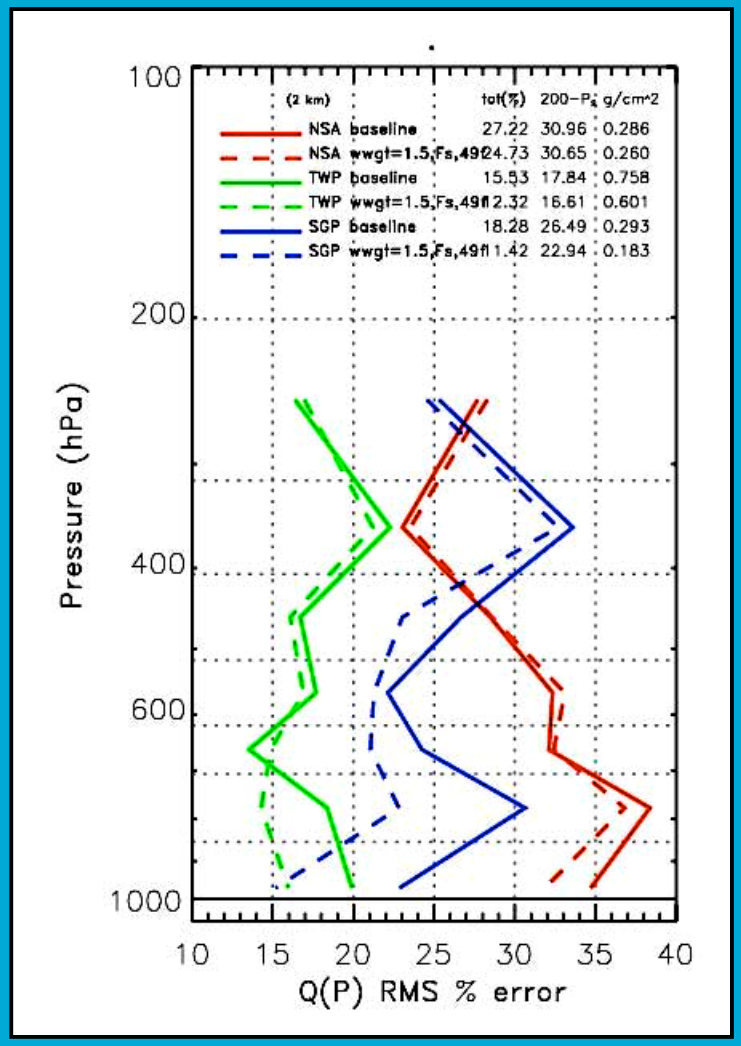
(20% biased regression result)

...+ Perturbation functions optimization



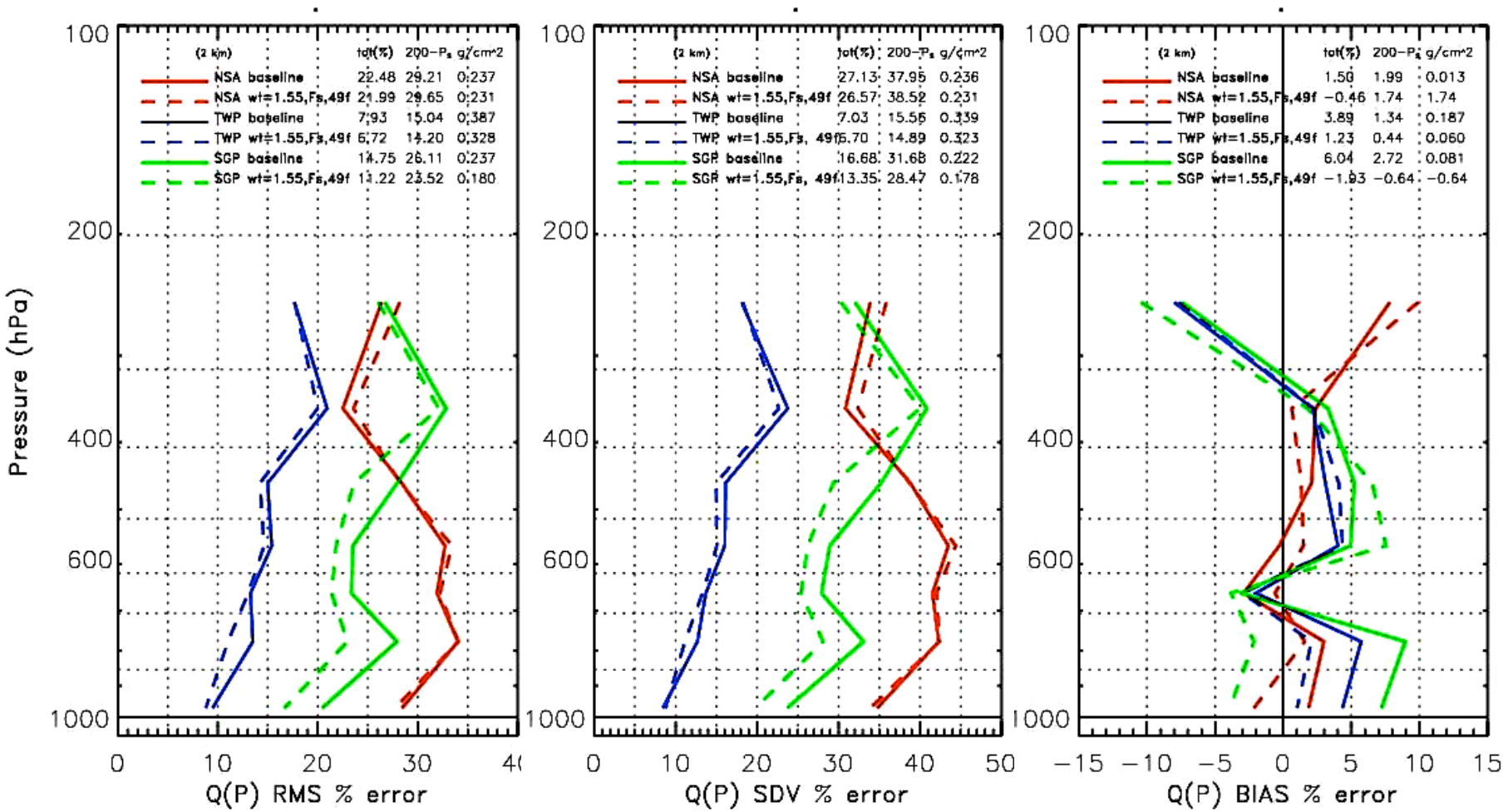
(20% biased regression result)

...+ Water channel list optimization



(20% biased regression result)

Comprehensive results



Conclusions toward version 6

- Over-damping in present configuration
- Adjustments in perturbation functions
- Possibility of capturing more information by adding more channels

Back up slides

New channels

	NSA	nsa pwat	comments	TWP	pwat	comments	SGP	pwat
1135.50	+		imp below 4	+	**666**		+	**845**
879.09	+	surface		+	**900**		++	**surface**
878.77	+			++			+	
774.99	+	**surf**		+	**815**		+	**surf**
780.15	+	**surf**		++	**851**		+	**surf**
839.92	+	**surf**			**755**	litt prob	+++	**995**
852.41	+	**surf**		++	**686**		+	**889**
878.44	+			++			++	

AIRS water vapor retrieval algorithm optimizations

- **The AIRS Product Retrieval Software (APS)** has been designed to derive several geophysical parameters including temperature and water vapour profiles, IR and microwave surface emissivity, total ozone and cloud parameters.
- This module solves for the solution of the linearized radiative transfer equation :

$$\Delta X_L = S^{-1}_{n,L} \cdot \Delta R_n$$

$$\Delta X_L = [S^T_{L,n} \cdot W_{n,n} \cdot S_{n,L} + H_{L,L}]^{-1} \cdot S^T_{L,n} \cdot W_{n,n} \cdot (\Delta R_n - \phi_n)$$

Possible optimization parameters:

- Channels Selection

- Perturbation Functions

- Regularization factor

Damping parameter

$$\Lambda_{k,k}^{s,i} \equiv \left(U_{k,j}^{T}\right)^{s,i} \left(S_{j,n}^{T}\right)^{s,i} \left(N_{n,n}^{s}\right)^{-1} S_{n,j}^{s,i} U_{j,k}^{s,i}$$

$$\Delta X_L^{s,i} = U_k^{s,i} \cdot \frac{1}{\Lambda_k^{s,i}} \cdot \left(U_k^{s,i}\right)^T \cdot \left(S_k^{s,i}\right)^T \cdot \left(W_{n,n}^{s,i}\right) \cdot \Delta R_n^{s,i-1}$$

Define Lambda critical = Define ΔX max

$\uparrow$ ΔX max $\downarrow$ λ_c^s $\downarrow$ (less) damping

Implications

- OLR differences of xx in rms, and yy in bias

a02asc:
OLR (W/m^2) 3 solutions 1 points 0 stats

true	guess 1		OLR 1		OLR 2	
mean	bias	rms err	bias	rms err	bias	rms err
263.91	-27.68	29.61	-14.07	19.33	-6.76	16.65

COLR (W/m^2) 3 solutions 1 points 0 stats

true	guess 1		OLR 1		OLR 2	
mean	bias	rms err	bias	rms err	bias	rms err
263.91	-13.97	16.09	-3.95	9.26	1.40	8.18

a96asc:
OLR (W/m^2) 3 solutions 1 points 0 stats

true	guess 1		OLR 1		OLR 2	
mean	bias	rms err	bias	rms err	bias	rms err
263.91	-27.68	29.61	-14.07	19.33	-6.67	16.59

COLR (W/m^2) 3 solutions 1 points 0 stats

true	guess 1		OLR 1		OLR 2	
mean	bias	rms err	bias	rms err	bias	rms err
263.91	-13.97	16.09	-3.95	9.26	1.56	8.22

- Total Column Water improvement of ~5% for SGP and TWP sites